



Showcase Demonstration CASE STUDY

a Program of the U.S. Department of Energy

THE CHALLENGE: OPTIMIZING ELECTRIC MOTOR SYSTEMS AT A CORPORATE CAMPUS FACILITY

Summary

Minnesota Mining and Manufacturing (3M), a multi-billion company that manufactures such well-known products as Scotch™ Magic Tape, Scotchgard™ Fabric Protector and Post-It® Notes, conducted an in-house motor system performance optimization project. Using a systematic facility-by-facility approach, the company formed a Motor Challenge team that evaluated approximately 1,000 electric motor systems in 29 buildings at the 3M Center to identify feasible projects. This case study reports on several projects implemented in Building 123, one of the first facilities evaluated as part of the project. Four key energy saving upgrades in Building 123 reduced electricity use by 41 percent and resulted in cost savings of \$77,554 per year. The systematic approach developed and experience gained in the Building 123 project was applied to other 3M facilities and demonstrates how a large industrial company can optimize performance of their electric motor systems at a campus-type facility. For all projects implemented at the 3M Center, electricity savings are estimated to be 10,821 MWh, which, combined with maintenance savings and reduced steam and chilled water use, resulted in annual savings of \$823,000.

Company Background

Ranked in the top 75 of the "Fortune 500" for both sales and net income, 3M is a multinational company with operations in 60 countries and 34 states. The company was founded in 1902, employs about 70,000 people worldwide, and manufactures more than 50,000 products and services for a



3M Center

wide variety of consumer, commercial, professional, and industrial markets. These products range from sandpaper, adhesives, and pressure-sensitive tapes to pharmaceuticals, electrical products, and heart-lung equipment.

Project Overview

This Showcase Demonstration project was conducted at 3M Center, the company's 7.5 million square foot corporate headquarters campus located east of St. Paul, Minnesota in

Project Profile

Industry:	Diversified product manufacturing
Process:	Facilities support
System:	Pump and fan
Technology:	VFDs, energy efficient motors, other system improvements

The energy savings network

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the suburb of Maplewood. The center employs approximately 12,000 employees and houses research and development facilities that produce research on a wide variety of new and improved products. Research pilot plant operations are used to test and develop methods of producing products commercially. The Center is also the site of corporate sales, marketing, human resources, and operations offices. Of the approximately 1,000 electric motor systems at 3M Center, 70 percent drive building support functions such as HVAC and water pumping, while the remaining 30 percent support research and development functions.

Building 123 occupies 528,750 square feet and accommodates research pilot plants, mechanical and electrical maintenance shops, laboratories, and support functions. This building was chosen for the Showcase Demonstration project because it was one of the first facilities reviewed by the 3M team, and contains electric motor systems that are representative of those throughout the rest of the campus.

Project Team

To comply with 3M's Corporate Energy Policy to "improve energy consumption efficiency, reduce cost, decrease capital investment, reduce environmental emissions, and conserve natural resources," the company voluntarily began the task of optimizing the electric motor systems at 3M Center. A cross-functional, cross-company Motor Challenge team was established in January 1994, led by four full-time 3M employees representing the Facilities Engineering and Plant Engineering Departments. The team also included an engineer from Northern States Power Company (NSP) that specializes in demand side management programs; a motor specialist from General Electric Supply Company, a subsidiary of General Electric that provided technical expertise; and an engineering specialist from Landis & Gyr, Inc., who designed, managed, and commissioned all the control system installations. The team's mission was to identify, justify, participate in funding, and implement all feasible projects that would increase the efficiency of motor-driven equipment at 3M Center.



SIC: Diversified product manufacturing

Products: Various consumer/commercial/industrial

Location: Maplewood, Minnesota

Employees: 12,000 (70,000 worldwide)

Showcase Team Leader: Steven Schultz

Company Energy Philosophy: To improve energy consumption efficiency, reduce cost, decrease capital investment, reduce environmental emissions, and conserve natural resources.

The Systems Approach and Showcase Projects

The systems approach involves more than just specifying energy efficient motors, other components, or trying to increase the performance of one part of a system. The systems approach is a way to increase the efficiency of an electric motor system by shifting the focus away from the individual elements and functions to total system performance.

Applying the systems approach may involve the following interrelated actions:

- Establishing current conditions and operating parameters;
- Determining present and future process production needs;
- Gathering and analyzing operating data and developing load duty cycles;
- Assessing alternative system designs and improvements;
- Determining the most technically and economical sound options, taking into consideration all of the subsystems;
- Implementing the best options;
- Assessing operations, energy consumption, and analyzing economics (validating performance);
- Continuing to monitor and optimize the system; and
- Continuing to operate and maintain the system for peak performance.

For each of the Motor Challenge Showcase Projects, an approach similar to this was utilized to varying degrees.

The Systems Approach

In May 1995 the project was accepted by the U.S. Department of Energy (DOE) as a Motor Challenge Showcase Demonstration Project. The results obtained in the project were reviewed by DOE's Independent Performance Validation (IPV) team. Unlike most Motor Challenge Showcase Demonstration projects, however, the primary purpose of this project was to emphasize the methodology that was developed to carry out a project of such magnitude, rather than a specific technology or application.

To identify projects which could increase productivity, and reduce energy consumption, cost, and emissions, the 3M Motor Challenge team developed a methodical building-by-building approach. This 9-step approach included:

- (1) Locating and identifying equipment;
- (2) Documenting the type of motor system, operational requirements and use (including field measurements), type of system and motor controls, and nameplate information;
- (3) Analyzing efficiency of existing system, operational use vs. operational need, and present energy consumption;
- (4) Developing technical options, evaluating alternatives, calculating savings, estimating cost to implement, and determining financial and operational feasibility;
- (5) Developing proposals and reports, including system description, opportunities for improvement, and recommendations;
- (6) Presenting feasible proposals to management for funding approval, following up, and obtaining authority for expenditure;
- (7) Implementing the projects;
- (8) Following up with measurements and monitoring, comparing actual savings to calculated savings, and reporting the results; and
- (9) Communicating activities and progress to steering committee and Building Energy Teams.

Together with building management, the team decided whether to implement a project based on the financial and operational evaluations. After project implementation, follow-up metering was conducted to verify that projected savings were achieved and that operation of the system was satisfactory.

Project Implementation

Using this systematic approach, the 3M Motor Challenge team identified numerous energy saving upgrade projects to implement in Building 123. Four of these improvements were chosen for an in-depth study by DOE's IPV team. They are:

Upgrade of Research Pilot Plant Air Supply. Air supply is maintained in a research pilot plant in Building 123 by nine 5-hp exhaust fans and one 40-hp makeup air fan. Air was previously supplied 24-hours per day at full speed. Ventilation requirements, however, depended on the level of activity in the process area. The team optimized the supply system by adding a direct digital control system (DDCS) that controlled the level of ventilation to the area based on whether the research pilot plant was in use. A timer in the DDCS initiated the turning on and off of some of the exhaust fans. The team also retrofitted the supply makeup air fan motor with a variable frequency drive (VFD), and

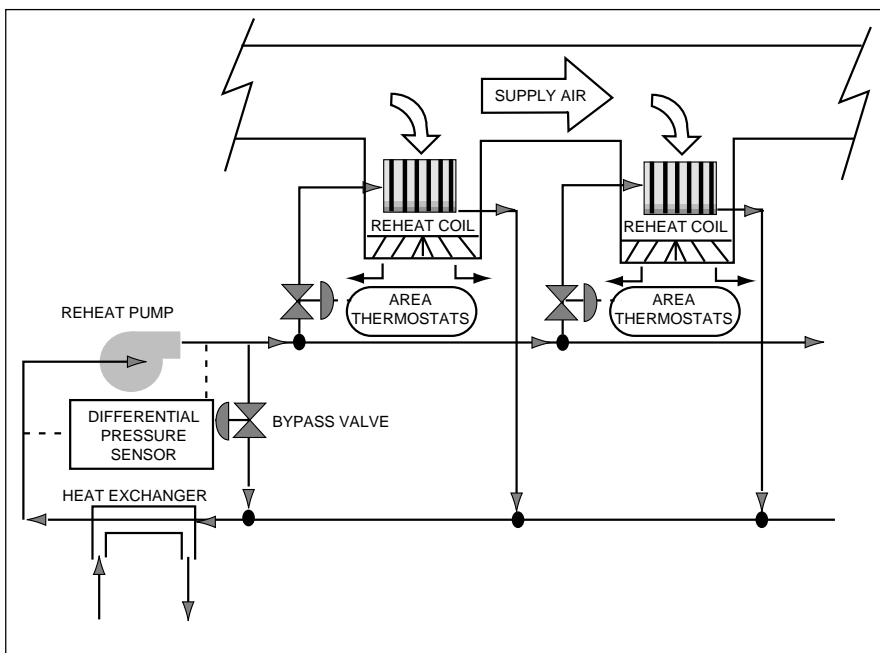


Research Pilot Plant Exhaust Fans

installed a differential static pressure sensor. The DDCS used a signal from the sensor to control the speed of the supply fan in order to maintain a slight negative pressure in the process area.

Upgrade of Reheat Water Supply System.

The reheat water supply system — part of the overall building HVAC system — pumps hot water to the building supply air reheat coils. The air supply flow to the reheat coils is constant, so temperature control is achieved by regulating the flow of hot water. The building has five reheat water supply pumping systems, each with two 7½-hp motors. Since continuously operating the pumps at full flow and diverting the unneeded flow through a bypass valve was clearly inefficient, the team optimized the system with energy-efficient motors and VFDs to better match the amount of water being pumped with the system requirements. In addition, tests conducted revealed that the system could perform satisfactorily with a lower differential pressure setting across the pump. This resulted in additional energy savings.



Reheat Water Supply System Diagram

Upgrade of Supply Air Fans. Air is supplied to many parts of Building 123 by two 50-hp fans. The volume of supply air required varies with the number of exhaust fans running, which in turn depends on process activity and building occupancy. Fans were run constantly and controlled with dampers. To optimize the system, the team installed a VFD on each fan to control the air flow more efficiently. The team also installed an energy-efficient motor on the one fan that did not already have one.

Energy-Efficient Motors Retrofit.

An evaluation of all electric motors in the building larger than 1½-hp identified 50 older, standard-efficiency motors that operated more than 6,000 hours per year and could therefore benefit from retrofit to energy-efficient motors. Twenty-eight of these motors were retrofit to energy-efficient motors and studied in detail as part of the Showcase project. An improvement of 2 to 5 percent was expected from each retrofit. In some cases other measures were



Supply Air Fan

taken, such as sheave changes to slow down the driven load, downsizing of the motor to more closely match system requirements, and repair and cleaning of components to reduce efficiency losses.

These four upgrade projects constituted a large percentage of the electrical and cost savings achieved in Building 123 and are typical of the projects identified and implemented at 3M Center. By focusing on these key upgrades, DOE's IPV team was able to validate the methodology used by 3M and quantify the savings achieved.

Results

Prior to the project, these four systems annually consumed a total of 2,292,745 kWh and had a maximum demand of 318 kW. Annual electric and utility costs totaled \$237,195. After the system optimization projects were implemented, electricity use was reduced by 41 percent and kW demand was reduced by 20 percent. In addition, steam and chilled water use were reduced in the two systems which heat or cool ambient air before supplying it to occupied space. Accounting for both electric and other utility savings, the optimization projects resulted in a total annual cost savings of \$77,554. After factoring in demand-side management incentives offered by Northern States Power, the net cost of the project to 3M was \$79,499. This yields a simple payback on all four projects of 1.03 years. The individual projects had simple paybacks of 1.35 years, 2.61 years, 0.81 years, and 3.06 years, respectively. In addition to saving energy, the projects also provided up-to-date information on the building's motor systems, identification of required maintenance (especially in the case of one of the building air supply fans), and additional savings from matching the flow or pressure supply to system requirements.



Energy-Efficient Motor

Performance Improvement Summary				
	Validated Projects		Entire Campus (Estimated)	
Annual Energy and Cost Savings				
Electricity	939,400 kWh	\$31,583	10,821,000 kWh	\$363,800
Utilities	Reduced steam and chilled water use	\$45,971	Reduced steam and chilled water use	\$441,200
Maintenance Savings				\$ 18,000
TOTAL		\$77,554		\$823,000
Total Annual Power Plant Emissions Reductions				
CO ₂		1,205,200 lbs		13,883,300 lbs
Carbon Equivalent		328,690 lbs		3,786,400 lbs
SO _x		2,900 lbs		34,000 lbs
NO _x		3,400 lbs		39,300 lbs
TSP		240 lbs		2,800 lbs
VOC		33 lbs		380 lbs

When applied to all buildings at 3M Center, the systematic approach to performance optimization is estimated to save approximately 10,821 MWh and reduce demand by 468 kW annually. With estimated annual savings of \$823,000 and a net project cost of \$1,600,000, the projects will have a net payback of 1.9 years.

Lessons Learned

In undertaking the projects in Building 123, a number of important lessons were learned and applied to optimization projects in the rest of the headquarters campus. Most importantly, the team learned to talk to the people who operate the equipment, gain their support, and involve them in the project. The team also learned that they should:

- (1) Consider differences in motor RPM carefully when considering replacing an existing motor with a new energy-efficient motor;
- (2) Have electrical contractors be the prime contractor and have them subcontract the rest of the work themselves;
- (3) Send the labor portion of the projects out for competitive bids; and
- (4) Use MotorMaster™ and other software to evaluate motor and VFD applications and benefits when doing initial savings estimates.

About Motor Challenge

The Motor Challenge is a joint effort by the U.S. Department of Energy (DOE), industry, motor systems equipment manufacturers and distributors, and other key stakeholders to put information about energy-efficient electric motor system technology in the hands of people who can use it.

Showcase Demonstration Projects target electric motor-driven system efficiency and productivity opportunities in specific industrial applications. They show that efficiency potential can be realized in a cost-effective manner and encourage replication at other facilities.

DOE provided technical assistance and independent performance validation (IPV) of energy savings. A DOE-sponsored IPV team reviewed the test plan and provided assistance, as requested by the host site, on testing procedures, instrumentation techniques, and data acquisition. The DOE team developed a detailed IPV Report thoroughly documenting the project. The Report is available by calling the number listed below. DOE did not witness the actual test data, and the conclusions in this case study are based solely on data provided by the host site and their partners.

For more information on becoming involved in the Motor Challenge or sponsoring a Showcase Demonstration, call the Motor Challenge Information Clearinghouse at (800) 862-2086.

Contact:
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September 1996



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ORNL/MC-CS2